CLAIMS

What is claimed is:

1. An optical communications link, comprising:

an optical transmitter for transmitting an optical signal;

an optical receiver for receiving said optical signal; and

an index-guiding optical fiber between said optical transmitter and said optical receiver, said index-guiding optical fiber comprising a microstructured core having at least 50 percent of its cross-sectional area occupied by voids.

2. The optical communications link of claim 1, wherein said optical transmitter is adapted to transmit an optical signal modulated at 10 Gbps or greater, wherein said optical transmitter and said optical receiver are separated by a distance greater than or equal to 100 km, and wherein no optical amplifiers or regenerators are required between said optical transmitter and said optical receiver.

3. The optical communications link of claim 2, wherein said optical signal has a center wavelength located within a transmission band of about 1530 nm – 1570 nm.

4. The optical communications link of claim 2, wherein said optical signal has a center wavelength located in a transmission band of about 1500 nm – 1600 nm.

5. The optical communications link of claim 4, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 10 Gbps or greater and spaced apart by at least 0.4 nm, whereby said optical communications link is capable of a data throughput up to 2.50 Tbps.

6. The optical communications link of claim 4, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 10 Gbps or greater and spaced by at least 4.0 nm, whereby said optical communications link is capable of a data throughput up to 250 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said optical transmitter

and optical receiver due to corresponding channel separations of at least about 500 GHz.

7. The optical communications link of claim 6, wherein said voids comprise a gas or vacuum.

8. The optical communications link of claim 6, wherein said voids comprise a liquid or solid having a lower index of refraction than that of silica glass.

9. The optical communications link of claim 2, wherein said microstructured core has at least 90 percent of its cross-sectional area occupied by voids, and wherein said optical transmitter and said optical receiver are separated by a distance greater than or equal to 300 km, with no optical amplifiers or regenerators being required between said optical transmitter and said optical receiver.

10. The optical communications link of claim 9, wherein said optical signal has a center wavelength located within a transmission band of about 1530 nm – 1570 nm.

11. The optical communications link of claim 9, wherein said optical signal has a center wavelength located within a transmission band of about 1500 nm – 1600 nm.

12. The optical communications link of claim 9, wherein said optical signal has a center wavelength located within a transmission band of about 1350 nm – 1600 nm.

13. The optical communications link of claim 9, wherein said optical signal has a center wavelength located within a transmission band of about 1200 nm – 1300 nm.

14. The optical communications link of claim 9, wherein said optical signal has a center wavelength located within a transmission band of about 900 nm – 1300 nm.

15. The optical communications link of claim 11, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals

modulated at 10 Gbps or greater and spaced apart by at least 0.4 nm, whereby said optical communications link is capable of a data throughput of up to 2.50 Tbps.

16. The optical communications link of claim 12, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 10 Gbps or greater and spaced apart by at least 0.4 nm, whereby said optical communications link is capable of a data throughput of up to 6.25 Tbps.

17. The optical communications link of claim 12, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 10 Gbps or greater and spaced by at least 4.0 nm, whereby said optical communications link is capable of a data throughput up to 625 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said optical transmitter and optical receiver due to corresponding channel separations of at least about 500 GHz.

18. The optical communications link of claim 1, further comprising a dispersion-compensating fiber interposed between said optical transmitter and said optical receiver, wherein said optical transmitter is adapted to transmit an optical signal modulated at 40 Gbps or greater, wherein said optical signal has a center wavelength located within a transmission band of about 1500 nm – 1550 nm, wherein said optical transmitter and said optical receiver are separated by a distance greater than or equal to 100 km, and wherein no optical amplifiers or regenerators are required between said optical transmitter and said optical receiver.

19. The optical communications link of claim 18, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 40 Gbps or greater and spaced apart by at least 1.6 nm, whereby said optical communications link is capable of a data throughput up to 1.20 Tbps.

20. The optical communications link of claim 18, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 40 Gbps or greater and spaced by at least 8.0 nm, whereby said optical

communications link is capable of a data throughput up to 240 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said optical transmitter and optical receiver due to corresponding channel separations of at least about 1 THz.

21. The optical communications link of claim 1, further comprising a dispersion-compensating fiber interposed between said optical transmitter and said optical receiver, wherein said microstructured core has at least 90 percent of its cross-sectional area occupied by voids, wherein said optical transmitter is adapted to transmit an optical signal modulated at 40 Gbps or greater, wherein said optical signal has a center wavelength located within a transmission band of about 1500 nm – 1570 nm, wherein said optical transmitter and said optical receiver are separated by a distance greater than or equal to 300 km, and wherein no optical amplifiers or regenerators are required between said optical transmitter and said optical receiver.

22. The optical communications link of claim 21, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 40 Gbps or greater and spaced apart by at least 1.6 nm, whereby said optical communications link is capable of a data throughput up to 1.20 Tbps.

23. The optical communications link of claim 21, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals modulated at 40 Gbps or greater and spaced by at least 8.0 nm, whereby said optical communications link is capable of a data throughput up to 240 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said optical transmitter and optical receiver due to corresponding channel separations of at least about 1 THz.

24. The optical communications link of claim 23, wherein said voids comprise a gas or vacuum.

25. The optical communications link of claim 23, wherein said voids comprise a liquid or solid having a lower index of refraction than that of silica glass.

26. A communications system, comprising:

a source transmitter for generating an optical signal at a source location;

a destination receiver for receiving said optical signal at a destination location; and

a plurality of regeneration spans sequentially coupled between said source transmitter and said destination receiver, each regeneration span comprising:

a regenerator for receiving, regenerating, and retransmitting said optical signal at an intermediate location between said source transmitter and said destination transmitter; and

a fiber optic span coupled between said regenerator and a regenerator associated with an adjacent regeneration span;

wherein said fiber optic span comprises an optical fiber having a core region in which a majority of the cross-sectional area is occupied by voids.

27. The communications system of claim 26, wherein said optical fiber has a cladding region in which a majority of the cross-sectional area is occupied by voids.

28. The communications system of claim 27, wherein said optical fiber has a dispersion magnitude of less than 10 ps/(nm-km) between 1100 nm and 1600 nm.

29. The communications system of claim 28, wherein said optical fiber has an attenuation magnitude of less than 0.20 dB/km between 1450 nm and 1600 nm.

30. The communications system of claim 29, wherein said optical signal is modulated at 10 Gbps or greater and is at a wavelength between 1100 nm and 1300 nm, wherein said regeneration spans do not include dispersion-compensating fibers or optical amplifiers, wherein said regeneration spans have a maximum regeneration span length corresponding to a maximum allowable distance between regenerators, and wherein said maximum regeneration span length is not less than 100 km.

31. The communications system of claim 30, wherein said optical fiber has a core region in which at least 90% of the cross-sectional area is occupied by voids, and wherein said maximum regeneration span length is not less than 250 km.

32. The communications system of claim 31, said optical signal further comprising a plurality of wavelength-division-multiplexed signals between 1100 nm and 1300 nm modulated at 10 Gbps or greater and spaced apart by at least 0.4 nm, whereby said communications system is capable of a data throughput of up to 5.00 Tbps.

33. The communications system of claim 31, said optical signal further comprising a plurality of wavelength-division-multiplexed signals between 1100 nm and 1300 nm modulated at 10 Gbps or greater and spaced by at least 4.0 nm, whereby said communications system is capable of a data throughput up to 500 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said communications system due to corresponding channel separations of at least about 500 GHz.

34. The communications system of claim 33, wherein said voids comprise a gas or vacuum.

35. The communications system of claim 33, wherein said voids comprise a liquid or solid having a lower index of refraction than that of silica glass.

36. The communications system of claim 29, wherein said optical signal is modulated at 10 Gbps or greater and is at a wavelength between 1450 nm and 1600 nm, wherein said regeneration spans have a maximum regeneration span length corresponding to a maximum allowable distance between regenerators, and wherein said maximum regeneration span length is not less than 100 km.

37. The communications system of claim 36, wherein said regeneration spans include dispersion-compensating fibers and at least one optical amplifier, wherein said regeneration spans have a maximum attenuation-limited amplifier spacing corresponding to a maximum distance between any two optical amplifiers or between an optical amplifier and a regenerator, wherein said maximum attenuation-limited amplifier spacing is not less than 100 km, and wherein said maximum regeneration span length is not less than 500 km.

38. The communications system of claim 37, wherein said optical fiber has a core region in which at least 90% of the cross-sectional area is occupied by voids, and wherein said maximum attenuation-limited amplifier spacing is not less than 250 km.

39. The communications system of claim 38, said optical signal further comprising a plurality of wavelength-division-multiplexed signals between 1450 nm and 1600 nm modulated at 10 Gbps or greater and spaced apart by at least 0.4 nm, whereby said communications system is capable of a data throughput of up to 3.75 Tbps.

40. The communications system of claim 38, said optical signal further comprising a plurality of wavelength-division-multiplexed signals between 1450 nm and 1600 nm modulated at 10 Gbps or greater and spaced by at least 4.0 nm, whereby said communications system is capable of a data throughput up to 375 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said communications system due to corresponding channel separations of at least about 500 GHz.

41. The communications system of claim 40, wherein said voids comprise a gas or vacuum.

42. The communications system of claim 40, wherein said voids comprise a liquid or solid having a lower index of refraction than that of silica glass.

43. The communications system of claim 29, wherein said optical fiber has a core region in which at least 90% of the cross-sectional area is occupied by voids, wherein said optical signal is modulated at 40 Gbps or greater and is at a wavelength between 1450 nm and 1600 nm, wherein said regeneration spans do not include optical amplifiers, wherein said regeneration spans have a maximum regeneration span length corresponding to a maximum allowable distance between regenerators, and wherein said maximum regeneration span length is not less than 30 km.

44. The communications system of claim 43, wherein said regeneration spans include dispersion-compensating fibers, and wherein said maximum regeneration span length is not less than 300 km.

45. The communications system of claim 44, said optical signal further comprising a plurality of wavelength-division-multiplexed signals between 1450 nm and 1600 nm modulated at 40 Gbps or greater and spaced apart by at least 1.6 nm, whereby said communications system is capable of a data throughput of up to 3.72 Tbps.

46. The communications system of claim 44, said optical signal further comprising a plurality of wavelength-division-multiplexed signals between 1450 nm and 1600 nm modulated at 40 Gbps or greater and spaced by at least 8.0 nm, whereby said communications system is capable of a data throughput up to 720 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said communications system due to corresponding channel separations of at least about 1 THz.

47. The communications system of claim 44, wherein said voids comprise a gas or vacuum.

48. The communications system of claim 44, wherein said voids comprise a liquid or solid having a lower index of refraction than that of silica glass.

49. The communications system of claim 44, said dispersion-compensating fibers having a dispersion of approximately –200 ps/(nm-km) or greater, wherein less than 3 km of dispersion-compensating fiber is required for each 300 km regeneration span.

50. The communications system of claim 49, wherein said dispersion-compensating fibers are equally distributed among, and co-located with, said regenerators.

51. An optical communications link, comprising:

an optical transmitter for transmitting an optical signal having a center wavelength between about 1450 nm and 1600 nm, said optical signal being modulated at 10 Gbps or greater;

an optical receiver for receiving said optical signal; and

an optical fiber between said optical transmitter and said optical receiver, said optical fiber having an attenuation of less than 0.04 dB/km and a dispersion magnitude of less than 2 ps/(nm-km) between 1450 nm and 1600 nm;

whereby said optical transmitter and said optical receiver may have a separation of up to 500 km without requiring optical amplifiers or dispersion-compensating fibers therebetween.

52. The communications link of claim 51, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals between 1450 and 1600 nm modulated at 10 Gbps or greater and spaced apart by at least 0.4 nm, whereby said optical communications link is capable of a data throughput up to 3.75 Tbps.

53. The communications link of claim 51, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals between 1450 nm and 1600 nm modulated at 10 Gbps or greater and spaced by at least 4.0 nm, whereby said communications system is capable of a data throughput up to 375 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said communications system due to corresponding channel separations of at least about 500 GHz.

54. The communications link of claim 52, wherein said optical fiber comprises a core region in which at least 90% of the cross-sectional area is occupied by voids.

55. The communications link of claim 53, wherein said optical fiber comprises a cladding region in which at least 90% of the cross-sectional area is occupied by voids.

56. The communications system of claim 55, wherein said voids comprise a gas or vacuum.

57. The communications system of claim 55, wherein said voids comprise a liquid or solid having a lower index of refraction than that of silica glass.

58. An optical communications link, comprising:

an optical transmitter for transmitting an optical signal having a center wavelength between about 1450 nm and 1600 nm, said optical signal being modulated at 40 Gbps or greater;

an optical receiver for receiving said optical signal;

an optical fiber between said optical transmitter and said optical receiver, said optical fiber having an attenuation of less than 0.04 dB/km and a dispersion magnitude of less than 2 ps/(nm-km) between 1450 nm and 1600 nm; and

at least one dispersion-compensating fiber interposed between said optical transmitter and said optical receiver;

whereby said optical transmitter and said optical receiver may have a separation of up to 300 km without requiring optical amplifiers therebetween.

59. The communications link of claim 58, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals between 1450 and 1600 nm modulated at 40 Gbps or greater and spaced apart by at least 1.6 nm, whereby said optical communications link is capable of a data throughput up to 3.72 Tbps.

60. The communications link of claim 59, said optical transmitter being further adapted to transmit a plurality of wavelength-division-multiplexed signals between 1450 nm and 1600 nm modulated at 40 Gbps or greater and spaced by at least 8.0 nm, whereby said communications system is capable of a data throughput up to 720 Gbps, and whereby lower precision, lower cost filtering equipment may be used in said communications system due to corresponding channel separations of at least about 500 GHz.

61. The communications link of claim 59, wherein said optical fiber comprises a core region in which at least 90% of the cross-sectional area is occupied by voids.

62. The communications link of claim 61, wherein said optical fiber comprises a cladding region in which at least 90% of the cross-sectional area is occupied by voids.

63. The communications system of claim 62, wherein said voids comprise a gas or vacuum.

64. The communications system of claim 62, wherein said voids comprise a liquid or solid having a lower index of refraction than that of silica glass.

65. An optical fiber comprising a core region having a first effective index of refraction and a cladding region having a second effective index of refraction less than said first effective index of refraction, wherein a majority of a collective cross-section of said core and cladding regions is occupied by voids.

66. The optical fiber of claim 65, wherein said optical fiber has an attenuation of less than 0.2 db/km and a dispersion magnitude of less than 10 ps/(nm-km) between 1450 nm and 1600 nm.

67. The optical fiber of claim 65, said optical fiber having an attenuation of less than 0.35 db/km and a dispersion magnitude of less than 10 ps/(nm-km) between 1100 nm and 1300 nm.

68. The optical fiber of claim 66, said optical fiber having an attenuation of less than 0.35 db/km and a dispersion magnitude of less than 10 ps/(nm-km) between 1100 nm and 1300 nm.

69. The optical fiber of claim 68, wherein said voids comprise a gas or vacuum.

70. The optical fiber of claim 65, wherein at least 90% of the collective cross-section of said core and cladding regions is occupied by voids.

71. The optical fiber of claim 70, wherein said optical fiber has an attenuation of less than 0.04 db/km and a dispersion magnitude of less than 2 ps/(nm-km) between 1450 nm and 1600 nm.

72. The optical fiber of claim 70, said optical fiber having an attenuation of less than 0.07 db/km and a dispersion magnitude of less than 2 ps/(nm-km) between 1100 nm and 1300 nm.

73. The optical fiber of claim 71, said optical fiber having an attenuation of less than 0.07 db/km and a dispersion magnitude of less than 2 ps/(nm-km) between 1100 nm and 1300 nm.

74. The optical fiber of claim 73, wherein said voids comprise a gas or vacuum.

75. An optical fiber comprising a core region having a first effective index of refraction and a cladding region having a second effective index of refraction less than said first effective index of refraction, wherein at least 90% of a collective cross-section of said core and cladding regions is occupied by voids, whereby said optical fiber has an attenuation of less than 0.04 db/km and a dispersion magnitude of less than 2 ps/(nm-km) between 1450 nm and 1600 nm, and whereby said optical fiber has an attenuation of less than 0.07 db/km and a dispersion magnitude of less than 2 ps/(nm-km) between 1100 nm and 1300 nm.

76. The optical fiber of claim 75, wherein said voids comprise a gas or vacuum.

77. A method of transmitting information within a band of wavelengths over an optical communication link between two stations separated by at least 50 km, comprising:

providing a continuous, index-guiding optical fiber between said stations, said fiber having at least half its cross-sectional area occupied by subwavelength microstructures having at least one dimension smaller than the wavelengths in said band;

transmitting modulated optical signals related to said information through said continuous fiber.

78. A method as in claim 77 in which the transmitting step comprises transmitting

wavelength-division-multiplexed optical signals.

79. A method as in claim 78 in which said providing comprises causing said continuous fiber to have an attenuation of less than about 0.2 db/km and a dispersion magnitude of less than about 10 ps/(nm-km) for optical signals having center wavelengths substantially throughout the range of about 1450 nm to about 1600 nm.

80. A method as in claim 78 in which said providing comprises causing said continuous fiber to have an attenuation of less than about 0.35 db/km and a dispersion magnitude of less than about 10 ps/(nm-km) for optical signals having center wavelengths substantially throughout the range of about 1100 nm to about 1300 nm.